DIFFERENTIAL ADRENOCORTICAL STRESS RESPONSES IN NAVAL AVIATORS DURING AIRCRAFT CARRIER LANDING PRACTICE

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DIFFERENTIAL ADRENOCORTICAL STRESS RESPONSES IN NAVAL AVIATORS DURING AIRCRAFT CARRIER LANDING PRACTICE[1]

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Summary.—Serum cortisol levels were measured in 9 Navy pilots and their flight officers during aircraft carrier landing practice in the two-man F-4B jet aircraft. The pilots showed an unequivocal adrenocortical stress response; the flight officers did not. The complex and hazardous task of carrier landing appears to be a considerably greater stress on the "executive" naval aviator (the pilot in control of the aircraft) than on his passive partner, although both are exposed to the same dangers. The findings of this study highlight the importance of the active versus the passive role as a determinant of stress intensity in human *S*s exposed to naturally occurring stress situations.

The human adrenocortical response to naturally occurring stresses of many different types has been well documented in numerous studies. Inter-individual differences in the amount of cortisol secreted also have been well documented. However, the possibility that varying role demands upon human *S*s in stress situations may be a major influence on their adrenal responses has been examined in only a few studies (Marchbanks, 1958; Bourne, *et al.*, 1968).

Previous investigations have shown that, if a pair of monkeys is subjected to a noxious stimulus in an avoidance situation, the "executive" monkey (the one permitted to press a lever to avoid the noxious stimulus to both) develops gastrointestinal lesions, whereas the other animal, which has no control over the stimulus, does not (Brady, *et al.*, 1958; Brady, 1966, 1967). This experimental method has been applied to pairs of human *S*s, one of whom was able to press a button to avoid a strong auditory stimulus to both, while the other *S* was a passive control (Davis & Berry, 1963). The "executive" members of the pairs were shown to have a significantly greater amplitude of gastric contractions than the control *S*s. A similar experimental paradigm is considered in our study, which examines the psychophysiological variable of adrenocortical response to a naturally occurring stress situation, paired Navy pilots and flight officers attempting their first aircraft carrier landings in the F-4B Phantom jet.

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The Navy F-4B Phantom II is a two-man aircraft. The pilot, in the front cockpit, has complete flight control. The radar intercept officer (RIO), in the rear cockpit, monitors the radar scope and other aircraft instruments but has no flight control. He does have excellent visibility. In an emergency the RIO can eject himself from the aircraft, a procedure not without hazard. The pilot can eject either himself alone, or both persons, if the need arises.

Landing planes on carriers has been shown to be one of the most demanding tasks required of naval aviators; carrier landing accidents resulted in 75 aircrew fatalities in 1964 (Brictson, 1967). Both day and night, the pilot must fly the last mile of final approach visually, without an automatic landing system. At one mile from touchdown the entire ship appears about the size of a pencil eraser held at arm's length; in the F-4B this last mile is covered in 36 sec. A bad approach may result in (i) a "wave-off" by the landing signal officer who flashes lights signalling the pilot to abort the landing attempt, (ii) a "bolter"—failure of the tail hook to engage the arresting cables necessitating flying off the end of the flight deck, (iii) a "ramp strike"—hitting the stern of the ship with consequent damage to aircraft and crew, or (iv) flying into the ocean with essentially no chance of survival. Failure to complete a successful landing after several attempts necessitates the pilot's returning to the naval air station to land before the plane runs out of fuel. Thus the hazards of an improper carrier landing are considerable; the RIO is aware of these hazards but must rely completely on the pilot's skill for his own personal safety.

Method

Blood samples were obtained from 9 pilots and 10 RIOs on a non-flying control day and immediately upon their exiting the aircraft after performing the following tasks, in chronological order: (i) night mirror landing practice (MLP) at the naval air station, (ii) day carrier landings, and (iii) night carrier landings (CARQUALS). All blood samples were obtained between 3 P.M. and 2 A.M.; the sera were immediately separated and stored at —20°C until analyzed for cortisol by the method of Clark and Rubin (1969).

Results and Discussion

The mean cortisol responses of the pilots are listed in Table 1. The t values and probability levels represent comparisons of the control mean to the mean of each of the three flying periods. Serum cortisol was significantly higher following all three flying periods compared to the non-flying day; a 230% increase over control occurred following the day CARQUALS.

Similar data for the RIOs are also presented in Table 1. In contrast to the pilots, there was no significant increase in mean cortisol level following any flying period compared to the non-flying day; only a 40% increase over control occurred following the day CARQUALS. Although the RIOs evidenced a higher mean cortisol level than the pilots on the control day, the pilots had a higher mean serum level than the RIOs following all three flying periods.

TABLE 1

MEAN SERUM CORTISOL LEVELS, STANDARD DEVIATIONS, *t* TESTS OF DIFFERENCES BETWEEN CORRELATED MEANS FOR CONTROL DAY COMPARED WITH FLYING DAYS, AND ONE-TAILED PROBABILITIES FOR PILOTS ($N = 9$) AND RIOs ($N = 10$)

Activity	Serum Cortisol (ug%)	*t*	*df*	*P*
	Pilots ($n = 9$)			
Control	4.03±1.64			
Night MLP	8.95±4.34	4.62	16	<.0005
Day CARQUAL	13.24±6.00	5.61	16	<.0005
Night CARQUAL	9.21±5.98	2.74	16	<.01
	RIOs ($n = 10$)			
Control	6.15±3.39			
Night MLP	5.22±3.29	0.74	18	N.S.
Day CARQUAL	8.58±4.99	1.32	18	N.S.
Night CARQUAL	7.96±4.11	1.02	18	N.S.

The mean cortisol levels in these *S*s were lower than the mean plasma 17-OHCS levels found in other groups of *S*s undergoing naturally occurring stresses (Hamburg, 1962; Rubin & Mandell, 1966; Miller, 1968; Mason, 1968; Rubin, *et al.*, in press). Three factors help account for this difference. First, the aviators in the present study were already experienced in the F-4B, so that some psychoendocrine adaptation to the stress of flying this aircraft probably had already occurred. Second, the blood samples were drawn late in the day and evening and not at the usual morning height of the circadian variation in plasma cortisol (Frank, *et al.*, 1966), as in most of these other investigations. Third, we used an analytic method specific for cortisol, thereby eliminating some steroids that contribute a small additional amount to plasma 17-OHCS.

The results of our study indicate that aircraft carrier landing practice is considerably more stressful for pilots than for their RIOs. In the context of the "executive" monkey paradigm, the "executive" naval aviator, who must perform a highly complex task while avoiding serious potential harm to himself, his partner, and his aircraft, shows an unequivocal adrenocortical stress response. The passive partner, on the other hand, although completely aware of the risks involved, shows only a slight, statistically insignificant adrenal response. These findings support the previous work on paired animal and human *S*s and point to the importance of the active versus the passive role as a determinant of stress intensity in human *S*s exposed to naturally occurring stress situations.

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